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PERSPECTIVES AND RECONCILATION OF VIEWPOINTS ON RISK ASSESSMENT ISSUES

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INTRODUCTION

As part of our Radioactive Waste Hazard Assessment project sponsored by the U.S. Department of Energy, we are conducting a review of risk assessments appearing in technical literature, policy statements, and publications of anti-nuclear and pro-nuclear groups. The objective of this work is to document and discuss the various views or perspectives expressed by groups and individuals on the radioactive waste problem. The study is expected to be completed by summer of 1980. This paper will present a preliminary discussion of some of the material in the overall study.

Risk assessment, as applied to nuclear reactor and fuel cycle operations, has resulted in divergent reaction from both the scientific community and the public at large. Risk assessment is a relatively new and growing area of study which attempts to provide a basis for placing reasonable perspectives on the hazards of complicated technological enterprises. The intent is to assist in formulating rational decisions and policies.

Risk assessment is composed of three separate but related areas of effort. Risk analysis or evaluation is the first component. It involves the quantitative evaluation of probabilities and consequences of undesired events, and may include large scale systems modeling, consequence prediction, probability analysis through fault tree/event tree modeling, sensitivity analysis, etc. Probabilistic risk analysis attempts to forecast the safety of complex systems for which significant uncertainty on the failure and/or consequence characteristics may exist.

The second component of risk assessment is perspectives study. This area of effort considers the results of the detailed risk analysis methodologies and evaluates these results through comparative analysis of the operation under study relative to risks for alternative systems, related systems or unrelated activities for which the degree of public acceptance

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is perhaps better understood. The perspectives studies are generally of a technical nature and do not attempt to incorporate risk preference/aversion or other perceptual factors.

Decision Analysis is the thirdcomponent of risk assessment. Decision analysis should be the final step of the risk assessment procedure. It involves the application of some form of utility theory to convert the risk perspectives into an optimal decision, with lateral input of a perceptual nature (risk aversion/preference, utility functions, political considerations, etc.). The procedure requires an explicit specification of the objective function, or set of desired attributes, along with their relative importance. Recognizing that zero risk is an unattainable goal in waste management or any other technological application, it becomes necessary to specify "how safe is safe enough", and to make judgments within that framework.

One approach would be cost-benefit analysis wherein an explicit economic value is placed on the potential adverse consequences to allow for objective comparison with the potential benefits of any operation.

This paper will first discuss the divergent viewpoints on risk analysis. It will then consider views that have been expressed in the literature on some of the issues that influence public opinion on waste management. The basic characteristics of the divergent viewpoints will next be considered. Finally, the problem of reconcilation will be discussed.

VIEWPOINTS ON RISK ANALYSIS

The basic methodologies of risk analysis - consequence prediction, probability evaluation, and the combination of these to provide quantitative values for risk - have generated both positive and negative opinions as to their validity in analyzing safety. These opposing viewpoints focus on non-technical as well as technical issues.

One type of negative reaction to risk analysis falls under the general category of anti-technology feelings. These opinions exist to some extent within the scientific community as well as in a large segment of the public. High technology is distrusted by many, and a complex field of study designed to rationally analyze the safety of a high technology venture is similarly the object of distrust. It may be debatable whether this distrust is justified; nonetheless, it presents a formidable challenge to the nuclear industry.

There is also a negative reaction from those who philosophically object to placing dollar values on human life. Without the use of such a common denominator, risk analysis could amount to comparing apples and oranges, a procedure many consider not to be fruitful. The fact that society, government agencies, and industries routinely make decisions based on dollar cost per death averted, seems to be ignored by those who object to such a basis in decisions involving nuclear power or certain other scientific applications.

On the more technical side, the extreme values encountered, particularly when considering the very low probability, high consequence range of the probability-consequence spectrum, have led some to question the validity of risk analysis. There is some feeling that these extreme values represent mathematical artifices as opposed to meaningful physical data. The process has been compared to the mathematically invalid extreme of multiplying zero times infinity.

Another negative viewpoint involves the issue of completeness. For a risk analysis to be accurate, it must include all possible events. It cannot omit extremely low probability events since they may be risk significant through correspondingly large consequences. Further, the sum of many relatively insignificant events could provide a significant contribution to the total. Obviously, the omission of risk significant events would result in an inadequate analysis. Since we can never be assured that the complete spectrum of events is included, from a practical standpoint, the methodology is questioned.

Uncertainty is another issue in the risk analysis area. Although probabilistic risk analysis presupposes uncertainty, there is some feeling that since one cannot precisely predict the future, the methodology is suspect. A related issue involves the lack of valid data on which to analyze both probabilities and consequences.

On the positive side, probabilistic risk analysis, although not perfect, is thought to be the best method available to evaluate the risk of complicated systems for which significant uncertainty may exist. It provides a rational basis for tackling problems where information is limited.

The risk analysis techniques, even if they don't result in an "exact" quantification of risk, can be conservatively used to bound the problem. This process can lead to a progressive improvement of our levels of understanding.

Finally, risk analysis provides a rational basis for obtaining a perspective on a given problem and this rational perspective is essential as an input to the decision making process.

One of the dangers in the use of risk analysis techniques results from the tendency toward making up for lack of insight with improved precision. Carrying out a computation to several "significant figures" will not result in better results if the basic model underlying the computation is flawed. This approach may be characterized as the GIGO phenomenon: Garbage In, Garbage Out.

VIEWPOINTS ON WASTE MANAGEMENT ISSUES

In order to place the results of risk analysis efforts in perspective, it is important to consider the viewpoints that exist on various waste management issues.

One of the basic issues appears to be the question of whether artificial radioactivity presents hazards of a fundamentally different form than other dangers which are naturally occurring and/or non-radioactive in nature. This issue involves the effects of low-level radiation exposure, and the basic nature of radioactivity and its effects on human beings. Concerns over the effects of radiation exposure are aggravated by its specter of invisibility, cumulative and delayed affects, carcinogenicity, mutagenicity, and deleteious effects to the population gene pool.

In any event, there appears to be a general impression that the overall toxicity and hazard of radioactive waste is such that any mistakes, if made, would result in a catastrophe of unprecedented dimensions to present and future generations.

On the other hand, data and calculations have appeared in the literature which indicate the toxicity of nuclear waste is significantly less than that of many non-radioactive materials routinely produced and accepted in our society. Also, the relative hazard of a typical radioactive waste repository is less than that of many naturally occurring mineral formations, according to some analyses. Other analyses have shown the toxicity of radioactive waste decreases relatively rapidly so that, in a few centuries, it is lower than that of the ore from which the reactor fuel originally came.

The time behavior of radioactive materials is another area that has generated a considerable amount of comment. Some have expressed the opinion that the hazard of radioactive material is related to its half-life. The long half-lives of some radionuclides (e.g., Pu-239, $T_{1/2}$ = 24,400 years) has led to description of radioactive waste disposal as a problem on a 250,000 year time scale, with the implication that toxicity persistence on this time scale is unprecedented in the history of human activities.

On the other hand, it has been pointed out that the absurdity of equating potential hazard to half-life is that, if carried to its extreme, the stable toxic elements with essentailly infinite half-lives would be considered to be the most hazardous substances. In this regard, it should be noted that specific activity is inversely proportional to half-life. In other words, the longer the half-life of any radionuclide, the <u>less</u> radioactive it is.

It has been suggested elsewhere that it may be appropriate to clasify materials according to half-lives as follows. The term radioactive would refer to materials with half lives up to 10^6 years. For half lives between 10^6 and 10^{12} years, the term "radio-passive" would apply. For half lives in excess of 10^{12} years, the term "radio-quiescent" would be used, recognizing that this class would include the so-called stable nuclides. In the extreme, there may be no truly stable material, since 10^{30} years has been reported to be the approximate half-life for decay of the proton itself.

The purpose of such a classification is to point out the arbitrary distinction between radioactivity and stability, and to handle the important differences in the radiotoxicity of the materials in the different categories. Iodine-129 may be considered as a case in point. If all the iodine atoms in the human body were iodine-129(a radio-passive nuclide with a half-life of 1.7×10^7 years), the amount present would still be below maximum permissible body burden levels. Another example in the radio-passive area is uranium-238; for this nuclide, the Maximum Permissible Concentration (MPC) is based on chemical toxicity, rather than radiotoxicity. In the radio-quiescent category, MPC levels for neodymium-144 and indium-115 are 14.5 and 59.2 kilograms per liter, respectively. These values would be impossible to attain considering the laws of solubility. Continuous exposure of the standard man to such MPC levels would surely result in death from causes other than radiation effects.

Another area of divergent opinion is on the questions of the quantity of radioactive wastes, and the costs of their management. Opinions on these issues run the complete spectrum between the extremes with a surprisingly large amount of opinion at the extremes.

Other issues of importance include the general area of risk characterization, the potential for catastrophe, uncertainty, waste form, the capability of government to regulate with credibility, the history of waste management operations, and various other non-technical issues. On each of these issues there exists a wide divergence of attitudes.

CHARACTERISTICS OF VIEWPOINT DIVERGENCE

It is interesting to attempt to characterize the opposing attitudes on waste management issues. To some extent, these attitudes can be classified as either optimistic or pessimistic, depending on how individuals view the severity of the problem.

One of the first generalizations which can be observed is that the pessimistic statements tend to be qualitative and colorful, while the optimistic statements tend to be quantitative and technical. At the extremes, the pessimistic statements can revert to unsubstantiated assertions and emotionalism, while the optimistic statements can become clouded by oversimplification and the expression of quantitative values with much higher precision than is justifiable.

Another characteristic that can be observed is that the optimistic statements tend to address individual issues while the pessimistic approach frequently relies on a conglomeration of issues.

The divergence of conclusions drawn from the same basic data is a particularly interesting characteristic of some of the statements on specific issues. For example, based on the actual volume of radioactive waste to be produced, one statement will conclude that this presents a serious problem, while another statement will conclude that this presents a situation which is quite manageable.

In some cases, statements are made which are demonstrably false, or at least technically incorrect, but nevertheless are effective in stimulating public opinion. For example, the statement is made that plutonium is the most toxic material known to man. Yet, it has been shown that, on a toxicity per unit mass basis, many materials are more lethal than plutonium, particularly via ingestion pathways. Nevertheless, there is a perception that plutonium is particularly insidious not only because of its incomparable toxicity, but also, according to the National Council of Churches, because of its "intrinsically evil" nature.

In other cases, statements that are technically correct are phrased in such a way as to infer conclusions which may be misleading. For example, one author implies that nuclear power is basicly inefficient in stating that it takes 25 billion fissions to produce the energy equivalent to the combustion of only one gallon of oil.

RECONCILIATION OF VIEWPOINTS

The reconciliation of divergent viewpoints presents some difficult challenges to those charged with decision making on behalf of the public. Some issues may be amenable to reconcilation while others are not. Fears and issues which are philosophical in nature do not have a definable technical base and therefore may defy resolution through technology. Political problems might find their best solutions in the political arena.

Within the scientific community, a certain degree of reconciliation should be achievable. In particular, unfounded assertions and improper numerical manipulation ought to be easily detected and revealed as such, through the standard procedures of scientific study. The elimination of these forms of "expert opinion" will greatly simplify the effort toward consensus of the remaining body of opinion.

Another problem related to the public perception of scientific activities is that when a high priority is given to a particular technical research program, it is inferred that the results of the program are critically needed in order to shape defensible public policy. From the efforts to develop increasingly stable waste forms, it might be inferred that failure to do so could result in dire consequences. Similarly, the efforts to assure complete isolation of waste might imply that complete isolation is really necessary. Yet, the results of several systematic risk analyses indicate that neither of these implications is valid by calculating that, even using pessimistic assumptions, containment failure would result in radiation exposures considerably lower than natural background.

It is interesting to note that the Reactor Safety (Rasmussen) Study, did not result in widespread acceptance of the relative safety of nuclear reactors despite the fact that the quantitative results of the study indicated a high degree of relative safety. Perhaps this is indicative of the difficulty of providing technical solutions to political or emotional problems.

Where widely divergent conclusions results from a commonly accepted basic data, further study of the accepted data would not appear to be of use in generating consensus. For this type of opinion divergence, a broader view of the issue may be required so that attention can be better focused on points where disagreement exists. There can be no reconciliation until individual issues in contention are identified and dealt with.

Where negative public opinion exists as a result of unfamliarity with technical areas, it would appear that public education could be useful toward gaining acceptance. Where the negative feelings are philosophical in nature, such efforts may be futile.

CONCLUSIONS

It is important to recognize the distinction between risk assessment and its components which include risk analysis, perspectives study, and decision analysis. This distinction reveals the complete framework that risk assessment entails in view of the steps required to achieve the ultimate goal of policy decision.

Divergence of opinion within the scientific community as well as the public at large is a characteristic of issues related to nuclear power. These divergent opinions exist in all phases of risk assessment - from risk analysis to perspectives study and finally in the decision making process.

The divergent opinions can largely be characterized as either optimistic or pessimistic in nature. They run the complete spectrum from qualitative to quantitative and from emotional to detached. The divergence of conclusions drawn from the same basic data is a particularly interesting characteristic of some of the statments on specific issues.

Reconciliation of divergent viewpoints presents some difficult challenges. It is doubtful that issues which have an emotional or philosophical basis can be resolved through technical efforts.

Public education on the technical issues might prove helpful. Although, in itself, this education may not lead to reconciliation of divergent public views, a general understanding of the issues might provide a sound basis for their eventual resolution.